Solar Energy Potential for Alberta

Projects supported in part
by the Alberta/Canada
Energy Resources
Research Fund

Alberta
ENERGY AND
NATURAL RESOURCES
Scientific and Engineering
Services and Research Division

86-04110/

ENR No. I/145

ISBN 0-86499-325-0

Disclaimer

The contents of this publication are based on the information and data obtained from, and the results and conclusions of, a research project conducted by an independent researcher with financial assistance from the Alberta/Canada Energy Resources Research Fund.

The contents of this publication do not necessarily reflect the views of the Government of Alberta, its officers, employees or agents or of the Alberta/Canada Energy Resources Research Fund Committee.

Neither the Government of Alberta nor its officers, employees or agents makes any warranty, express or implied, representation or otherwise, in respect of, or assumes any liability for, the contents of this publication.

Foreword

Since 1976 numerous projects have been initiated in Alberta by industry and by academic research institutions which are aimed at better utilization of Alberta's energy resources.

These research, development and demonstration efforts were funded by the Alberta/Canada Energy Resources Research Fund (A/CERRF), which was established as a result of the 1974 agreement on oil prices between the federal government and the producing provinces.

Responsibility for applying and administering the fund rests with the A/CERRF Committee, made up of senior Alberta and federal government officials.

A/CERRF program priorities have focused on coal, energy conservation and renewable energy and conventional energy resources. Administration for the program is provided by staff within the Scientific and Engineering Services and Research Division of Alberta Energy and Natural Resources.

In order to make research results available to industry and others who can use the information, highlights of studies are reported in a series of technology transfer booklets. For more information about other publications in the series, please refer to page nine.

Solar Energy Potential for Alberta

Making the best use of Alberta's energy resources not only implies careful husbanding of conventional fossil fuel supplies but it also infers optimal use of alternative energy sources such as the sun.

Despite Alberta's northerly location, the substantial quantities of sunshine that are received each year make it practical to consider solar energy as a potential energy option.

In order to assess solar energy prospects and to develop technologies that show some promise, the A/CERRF Committee funded five projects during the period 1977 to 1985.

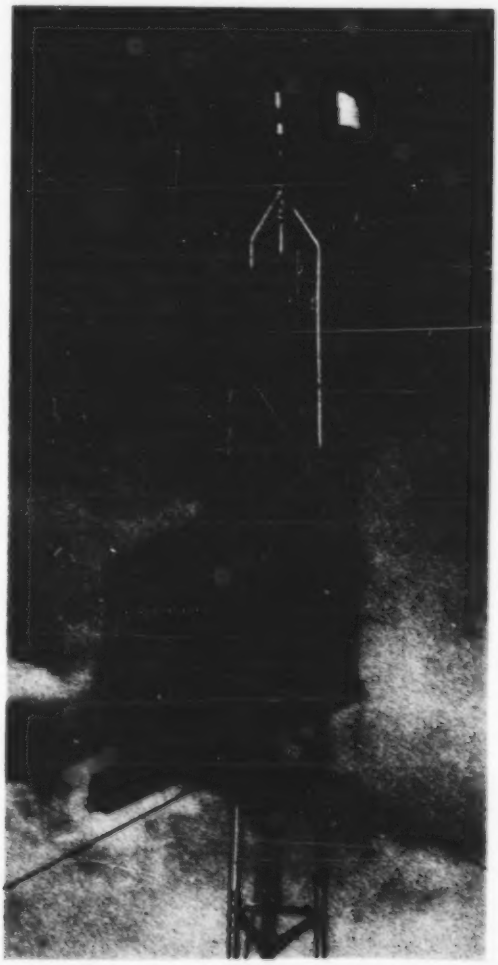
These endeavours ranged from an eight-year monitoring study of the components of solar radiation at several locations in Alberta to the first steps in developing an automated controller that would allow storage and controlled distribution of heat produced by solar collectors. Other work resulted in a sizeable library of solar energy publications while university researchers mapped the province's solar energy resources and showed how solar collection was possible in a region that experiences long, cold winters.

A typical solar and wind energy monitoring station.

Solar and Wind Energy Research Program (SWERP)

Designers and users of solar energy systems need information about solar energy intensity at specific locations because it is a function of latitude, the time of day and year and the amount of atmospheric absorption and scattering.

Because solar radiation can be employed in applications ranging from crop drying to residential heating, merely recording the annual hours of sunshine at a particular location does not provide the proper type of information. Rather, the individual components of radiation must be measured, too, because the importance of each element varies with the specific solar energy application.



Instruments at one of the SWERP monitoring stations were powered by arrays of photovoltaic cells.

Beginning in 1977, A/CERRF funded detailed measurements of Alberta's solar energy resource at six — eventually, seven — locations under the SWERP Monitoring Project carried out by Alberta Research Council. SWERP gathered data such as global solar radiation, sky radiation, reflected radiation, net radiation and daylight illumination. This information, which supplemented data available from the Atmospheric Environment Services of Environment Canada, was collected over a period of eight years until 1985.

Concurrent with the monitoring program, the SWERP Information Centre and Data Base was established at Alberta Research Council to provide a central source of research documents on solar energy that would be accessible to anyone involved in uses for renewable energy. Eventually, the collection of periodicals grew to 9100 books, journals, government reports and related articles on solar and wind energy projects. Typically, more than 1,000 requests for information were received each year.

In January 1986 the SWERP Information Centre was transferred to the Science and Technology Library of the University of Alberta, where extended open hours make access more convenient. The data base is available for searching through SPIRES (Stanford Public Information Retrieval System) at University of Alberta's computing services section.

Library services, formerly available from the SWERP Information Centre, are now provided by the Science and Technology Library at the University of Alberta.

Control Strategies for Solar-Assisted Heat Pumps

A computer simulation study carried out by the Department of Electrical Engineering at the University of Alberta attempted to formulate appropriate control strategies that would allow a solar-assisted heat pump system to heat a building. Controlling a system of this kind, where solar-derived heat is stored for a day or more and then released on demand, represents a non-linear process for which original mathematical models had to be developed.

After appropriate models were devised, computer simulations were done of a solar heating system under typical meteorological conditions common to Edmonton.

The control strategy resulted in a 30 per cent improvement in consumed energy when compared with the best control scheme known to exist when the study began. While the improvement was insufficient to make solar systems cost-competitive with heating schemes that use natural gas, a subsequent study which used groundwater as a heat source and employed a variation of this control strategy has proved to be so promising that a control device will be built and perhaps sold commercially.

A Solar Energy Atlas for Alberta

Hourly meteorological observations supplied by the Canadian Climate Centre and data gathered by the SWERP Monitoring Project were incorporated into a Solar Energy Atlas for Alberta. The 350-page atlas, which was compiled by the Department of Geography at the University of Calgary and completed in 1981, presents solar data in diagram form as well as in tables and maps. For the first time in one publication designers of solar systems can find the number of sunshine hours at locations throughout Alberta for each month plus global, diffuse and direct horizontal radiation. Users can find values for daily insolation at specific locations and can obtain all-important information about radiation incident on sloped collecting surfaces for elevations ranging from horizontal to vertical for every month of the year. Serious investigators would be well-advised to add the atlas to their collection of reference texts.

December Mean Global Radiation

Radiation is measured in Langley units.

One Langley unit equals one calorie per square centimetre.

(Source: *Solar Energy Atlas for Alberta*, L.C. Nkemdirim, 1981)

June Mean Global Radiation

Radiation is measured in Langley units.
One Langley unit equals one calorie per square centimetre.

(Source: *Solar Energy Atlas for Alberta*, L.C. Nkemdirim, 1981)

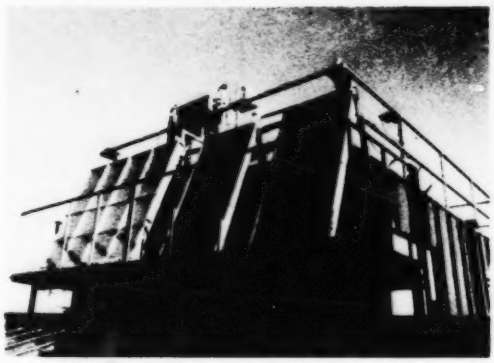
Solar Collectors for Cold Regions

Using water as the heat exchange medium in solar collectors may be fine for warm climates but in Alberta year-round recovery of heat from solar collectors demands a substance that won't freeze.

In a study conducted by the Department of Mechanical Engineering at the University of Alberta, simultaneous performance tests were done on hydronic solar systems using propylene glycol and on closed loop, two-phase Thermosyphon flat plate systems using refrigerant. The operating characteristics of the two-phase system were also studied during indoor tests. As heat exchange media underwent phase transitions between gas and liquid — caused by evaporation or condensation in the same way that a refrigerant behaves in refrigerators — heat was transferred from the solar collectors to a water-filled storage tank.

The absorber plate temperature for two-phase systems was found to be lower with less heat loss than in conventional, hydronic systems. Using FREON R-11, heat recovery rates of up to 75% were obtained. Furthermore, refrigerant-charged solar collectors proved to be less complicated than traditional hydronic systems, because pumps, controls and check valves were not required.

While the two-phase concept may not be practical for solar systems in Alberta at this time — mainly because of low costs for natural gas — this study was followed by an investigation funded by another agency, which showed the Thermosyphon concept could be used to extract heat from low-grade heat sources.



Two-phase Thermosyphon solar collector (left) and conventional collector (right) were used in a University of Alberta study of solar collectors for cold regions.

Control room with storage tanks used in University of Alberta solar collector study.

Indoor test facility used to study two-phase solar collectors at the University of Alberta.

Air-Mediated Solar Heating Systems

Another way to avoid problems with media that freeze is to use air instead of water in a solar system. A University of Alberta study conducted by researchers in the Department of Electrical Engineering asked whether an air-mediated solar collection scheme could supply annual requirements for space heating and hot water in single family homes by storing heat during summer months and releasing it over the winter when solar insolation is at its lowest. It was concluded the concept was technically feasible but costs were substantially higher than conventional oil- or gas-fired systems.

Computer analysis of 10 Canadian locations where solar radiation conditions were known — including Edmonton and Suffield — showed that Alberta was the least appropriate region for solar energy recovery using air-mediated collectors. This was due mainly to payback periods that were so long they approached the estimated lifetime of solar collectors and capital and operating costs for solar systems that were from three to nine times as expensive as natural gas heating schemes.

On a more positive note, the analysis revealed that if any region of the country were to be chosen as the most appropriate locale for solar systems, it would be the Atlantic provinces, where costs for air-mediated systems were either almost the same as, or up to four times the cost of, oil-fired systems now in use.

Conventional fossil fuels are undoubtedly the most important energy resource in Alberta today and they will be for years to come, but the studies described in this booklet show that Alberta has yet another energy source that can be relied upon in the future.

To obtain more information, consult the following contacts:

1. The SWERP library has been relocated to:

   University of Alberta
   Science and Technology Library (Cameron)
   2nd Floor
   Edmonton, Alberta T6G 2E1

   Telephone: (403) 432-4174

   The SWERP on-line data base may be accessed through:

   Data Librarian
   University of Alberta Computing Services
   Edmonton, Alberta T6G 2E1

   Telephone: (403) 432-3884

   To obtain access to SWERP monitoring data, contact:

   Industrial Development Department
   Alberta Research Council
   250 Karl Clark Road
   Edmonton, Alberta
   T6N 1E4

   Telephone: (403) 450-5370

   or in Calgary at:

   3rd Floor, Digital Building
   6815 - 8th Street N.E.
   Calgary, Alberta
   T2P 7H7

   Telephone: (403) 297-2600

2. Specifics about the *Solar Energy Atlas for Alberta* may be obtained from:

   Dr. Lawrence C. Nkemdirim
   Department of Geography
   University of Calgary
   2500 University Drive, N.W.
   Calgary, Alberta T2N 1N4

   Telephone: (403) 220-5584

3. Regarding *Application of Boiling and Condensation Heat Transfer to Flat Plate Solar Collectors in Cold Regions*, contact:

   Dr. K.C. Cheng
   Department of Mechanical Engineering
   University of Alberta
   Edmonton, Alberta T6G 2G8

   Telephone: (403) 432-3638

4. Details concerning the *Study of Air-Mediated Solar Heating Systems with Long-Term Storage* are available from:

   Dr. A.M. Robinson
   Department of Electrical Engineering
   University of Alberta
   Edmonton, Alberta T6G 2E1

   Telephone: (403) 432-4662

5. For more information about *A Study of Improved Control Strategies for Bilinear Heat-Transfer Processes in a Solar-Assisted Heat Pump System*, contact:

   Dr. R.E. Rink
   Department of Electrical Engineering
   University of Alberta
   Edmonton, Alberta T6G 2E1

   Telephone: (403) 432-5368

Additional copies of this publication are available from:

Alberta Energy and Natural Resources
Information Centre
Main Floor, Bramalea Bldg.
9920 - 108 Street
Edmonton, Alberta
T5K 2M4

Telephone: (403) 427-3590

For more information about A/CERRF, contact:

Director, Energy Conservation and Renewable
Energy Research
Scientific and Engineering Services and Research Division
Alberta Energy and Natural Resources
2nd Floor Pacific Plaza
10909 Jasper Avenue
Edmonton, Alberta
T5J 3M8

Telephone: (403) 427-8042